Evaluation of Golf Putting Green Management Systems with Reduced Chemical Pesticide Inputs[1]

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INTRODUCTION

This project provides information from the fourth year of a study assessing the feasibility and performance of golf course turf managed with an IPM approach utilizing population-based pest management to a system that utilizes biologically-based controls and reduced risk chemistry. The work was initiated on the Green Course at the Bethpage State Park, Long Island, New York in 2001. The Green Course is on of five public courses at the Park and accommodates approximately 50,000 rounds of golf annually. The greens are push-up native soil greens that have been heavily sand top-dressed for the last six years, and is typical of a high-use public course in a northern metropolitan community. A more detailed discussion of methodology and results from 2001 through 2003 can be found at http://usgatero.msu.edu/.

RESEARCH METHODOLOGY

Management Practices

The experiment was designed as a 3 x 2 factorial, with three pest-management and two cultural-management regimes.

Pest Management

Unrestricted: All legal and currently available chemical pesticides in New York State may be used.

IPM: Cultural and biological approaches to prevent and minimize pest problems were emphasized, but any legal practice or pesticide could be used.

Bio-Based Reduced Risk (formerly non-chemical treatment):Cultural and biological approaches to prevent and minimize pest problems were emphasized, but reduced risk chemical pesticides were used occasionally to prevent turf loss.

Cultural Management

Current Standard: Cultural practices currently being employed at the golf courses of the Bethpage State Park.

Alternative: Modified cultural practices; selected to reflect the most progressive practices that maximize turfgrass performance and minimize stress to the grass.

The experimental design resulted in six management systems. Each green served as a replicate, with all18 greens of the Bethpage Green Course used to accommodate 3 replications of the 6 management systems. After the first season, the greens in the alternative culture, nonchemical (now “reduced risk”) system were regrassed with velvet bentgrass (SR 7200) sod. In 2004, the “non-chemical” treatments were modified to “reduced risk” in recognition of the challenges in maintaining the integrity of the non-chemical treatments. After three years of

[1] This work was funded by the United States Golf Association (USGA) and the NYS IPM Program, and this report was previously submitted to the USGA.

attempting to manage a 70-yr. old mixed stands of bentgrass and annual bluegrass without synthetic pesticides, in this climate, it became apparent this was not sustainable with current technology. We felt that a viable interim approach was to avail the project of tools designed to select very low risk products, even if the treatments were no longer technically “non-chemical”.

In 2004 we introduced a significant change in the project, the use of the “Environmental Impact Quotient” (EIQ) (Kovach et al. 1992), to select the lowest-impact pest management products and practices in the IPM and reduced risk treatments. The EIQ model provides information on pesticides that will have the least harmful effects on non-target organisms, applicators and golfers. The superintendent chooses the lowest risk product amongst the legal products expected to be efficacious under the specific circumstances encountered.

This year, using the EIQ as a selection tool, preemptive strategies were used to prevent severe quality loss in the reduced-risk treatments, including the use of reduced risk pesticides such as Endorse and Alude from Cleary Chemical Co.

In addition to reduced risk chemistry, an intensive biologically based program was initiated utilizing *Pseudomonas aureofaciens* TX-1 through the Bio-Ject System from TurfLabs of California. The TX-1 was applied to the poa/creeping bentgrass greens three times weekly in the evening. Other biological products included EcoGuard (Bacillus licheniformis) from Novozymes, Sustane organic fertilizer as well as kelp-based fertilizers to enhance microbial activity.

RESULTS

Turf Quality

Two significant weather-related issues influenced the project in 2004. First, severe winter injury resulted from prolonged ice cover and ensuing desiccation killed significant portions of several greens in the study, as well as other areas of the park. Secondly, cool wet weather delayed spring recovery of the winter-injured areas and reduced some pest pressures while increasing others.

Table 1. Turfgrass quality* of putting greens, 2004

Treatment#	5-Apr	12-May	10-Jun	24-Jun	8-Jul	22-Jul	19-Aug	6-Oct
#1 UNRS	5.7	6.1	6.5	7.1	7.7	8.0	7.3	6.7
#2 UNRA	5.6	6.9	6.3	7.5	7.6	7.5	6.9	6.7
#3 RRS	5.6	5.8	6.4	7.1	7.4	7.5	6.9	6.7
#4 RRA	5.7	6.1	6.5	7.0	6.2	6.8	6.8	6.3
#5 IPMS	5.4	6.1	6.4	7.2	6.8	7.2	7.0	6.6
#6 IPMA	5.9	6.4	6.5	7.6	7.8	8.1	7.8	6.9
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

#UNRS= unrestricted pest mgt and standard culture; UNRA=unrestricted pest mgt. alternative culture; RRS=reduced risk pest mgt standard culture; RRA=reduced risk pest mgt. Alternative culture; IPMS=IPM pest mgt and standard culture; IPMA= IPM pest mgt and alternative culture.

*Turfgrass quality ratings on a scale of 1-9 where 1= poorest quality, 9= highest quality and 6= acceptable quality.

Quality in all treatments improved in 2004 as compared to the first three years (2001-2003 data not shown). Quality did not differ significantly among treatments at any sampling time (Table 1). Severe winter injury reduced overall visual quality ratings for several greens throughout the season, most notably on #3, an IPM standard culture green. In addition, the micro-environment around the 9th green (unrestricted pm, alternative culture) was significantly altered by tree and under-story removal that appeared to result in season-long chlorosis of the annual bluegrass. This response is typical of an annual bluegrass population that has adapted to a light and air deficient environment. Average visual quality ratings were only below the acceptable in the early season, when damage from winter injury lingered.

Ball roll measurements showed a significant increase from previous seasons where ball roll measurements rarely exceeded eight feet. In 2004 the velvet bentgrass greens produced some of the highest ball roll measurements (Table 2). However, there were only two dates where the differences between the treatments could be realistically distinguished by the average golfer.

Table 2. Ball roll measurements from 2004 treatments.

Treatment	10-Jun	24-Jun	8-Jul	22-Jul	19-Aug
#1 UNRS	8.2	7.8	8.2	8.2	8.1
#2 UNRA	7.6	8.0	8.5	8.5	8.1
#3 RRS	7.9	8.0	8.1	8.3	8.1
#4 RRA	8.2	8.6	7.9	9.1	8.5
#5 IPMS	7.9	8.0	8.2	8.4	8.2
#6 IPMA	8.1	7.5	7.7	7.8	8.0
LSD (0.05)	NS	0.6*	NS	0.7**	NS

Labor and Pest Populations

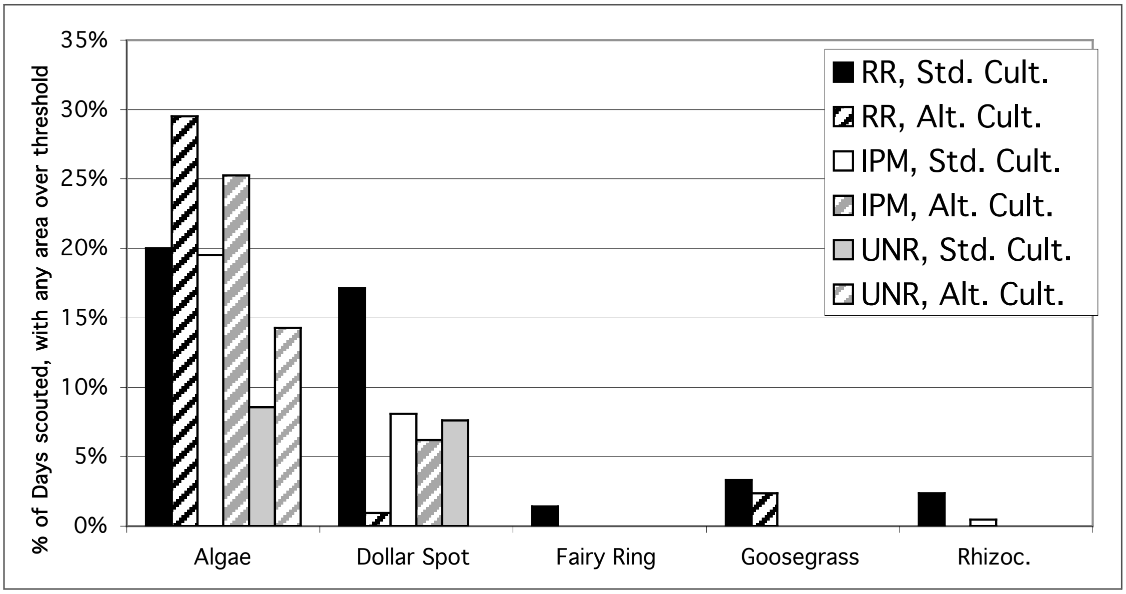
Overall, increased labor resources allowed for more consistent implementation of cultural management—most notably nutrient management. In addition, light frequent rates of Primo (trinexapac-ethyl) a plant growth regulator, known to enhance annual bluegrass health were applied throughout the season.

Intriguingly, dollar spot and Rhizoctonia incidence and severity were lower than previous seasons suggesting that an overall shift in less susceptible populations may be underway as dollar spot levels were severe throughout the northeast region and specifically in other areas of the park. Cutworm populations were also remarkably low, with damage exceeding threshold levels only on the velvet greens.

While major foliar diseases seemed to subside in 2004, root infecting pathogens that thrive in wet soils, such as summer patch, appeared to infect annual bluegrass early and plague the surfaces throughout the season. Although summer patch incidence was not widespread enough to warrant graphing, it contributed to quality loss at times on two IPM greens that were not sprayed preventatively.

Pest incidence, shown as the average percent of days scouted when any area of the green had any area over threshold (Figure 1), indicates a myriad of challenges. For example, algae incidence was high in all treatments, especially reduced risk and IPM greens. Dollar spot levels were the lowest of all four years of the experiment; were highest on the reduced risk poa/creeping bentgrass greens; and never over threshold on the unrestricted alternative culture greens. Fairy ring and Rhizoctonia incidence were notable only on the reduced risk poa/creeping bentgrass greens; whereas goosegrass has encroached in both the reduced risk treatments—a sign of the thinning that has occurred. Annual bluegrass was only considered a weed on the velvet bentgrass greens, and was over threshold 79% of the year.

Figure 1. Pest Incidence, % days with any area of green over threshold, 2004



Pesticide Use

The total number of pesticide applications to the reduced risk (formerly nonchemical) greens (Table 3) indicates an interesting difference between Velvet bentgrass and annual bluegrass/creeping bentgrass greens. Pesticides were considered "reduced risk" if classified as such by the EPA. Four to five chemical fungicides, and five to ten reduced risk fungicides, were applied to both the standard culture (poa/creeping bentgrass) and alternative culture (velvet bentgrass) greens. In addition, the poa/creeping bentgrass greens received 37 bio-fungicides, 95% of which were *Pseudomonas aureofaciens* TX-1 (applied three times weekly).

Table 3. Number of Pesticide Applications on Reduced Risk Greens in 2004

	Poa/creeping bent	Velvets
Chemical Insecticide	0.33	0
Chemical Herbicide	0.10	0
Chemical Fungicide	4.32	4.66
	4.8	**4.66**
Reduced Risk Insecticide	0	1.0
Reduced Risk Fungicide	10.0	5.0
Bio Fungicide	37.0	0
Total Apps.	**51.8**	**10.7**

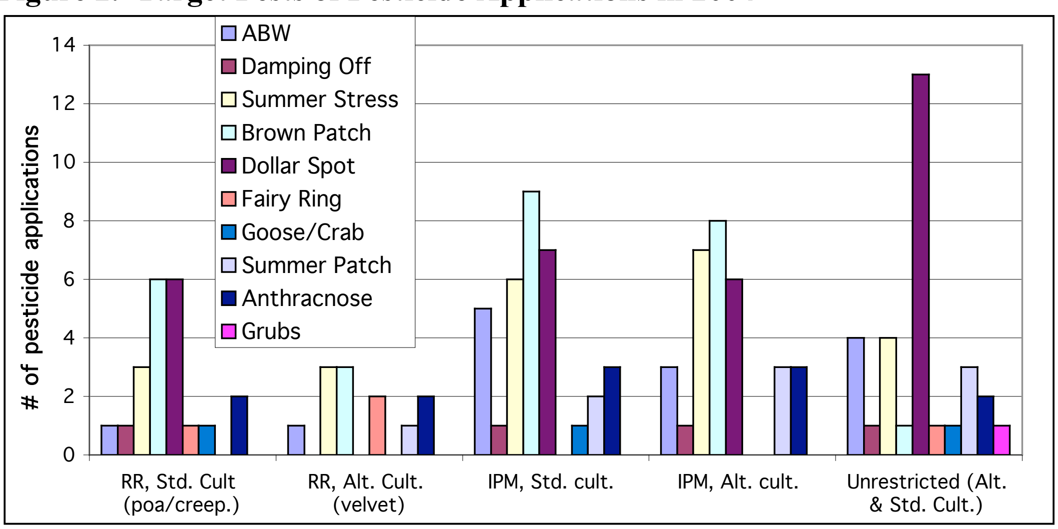
The number of pesticide applications to IPM and unrestricted greens indicate the heavy reliance on standard fungicides. Chemical pesticide applications were reduced by 54-57% in the IPM treatments, significantly better than previous years. This is largely due to a shift to using reduced risk and bio-pesticides. If all pesticides are included with the standard chemical pesticides, the reduction in applications is only 3-6% in the IPM treatments. To measure the value of this reduction in terms of environmental impact, we have calculated the EIQ values of each system.

Table 4. Number of Pesticide Applications on Unrestricted and IPM Greens in 2004

	Unrestricted	IPM Standard (%reduction)		IPM Alt. (%reduction)	
Chemical					
Insecticide	5.00	2.99	40%	2.67	47%
Herbicide	0.10	0.10	0%	0	100%
Fungicide	16.76	6.33	62%	7.33	56%
TOTAL	**21.9**	**9.4**	**-57%**	**10.0**	**-54%**
Reduced Risk					
Insecticide	0	0		0	
Fungicide	2.00	15.00		15.00	
Bio Fungicide	2.00	0		0	
TOTAL APPLICATIONS	**25.86**	**24.42**	**-6%**	**25.00**	**-3%**

Dollar spot continues to be the main target of pesticide applications (Figure 2) in the unrestricted treatments, and among the top three for all other treatments, while dollar spot occurrence was lower than in all other years. It appears that dollar spot management was more effective than previous years in all treatments, and that the high number of applications in the unrestricted treatments may be unwarranted.

Figure 2. Target Pests of Pesticide Applications in 2004

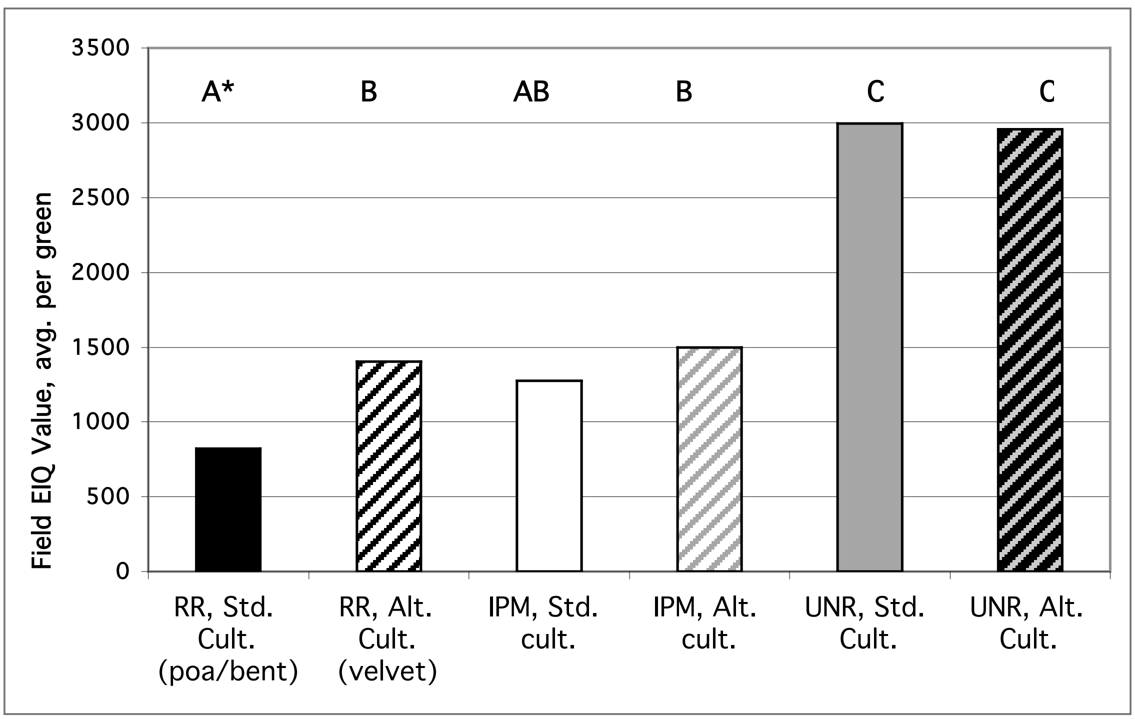


Environmental Impact

Comparing the number of pesticide applications is a fairly arbitrary method for assessing pesticide use when a variety of products are being used, and does not account for the impact of those applications. However, we and many other researchers have used that method because of a lack of better tools for assessing and comparing impact.

In 2004 we used the Environmental Impact Quotient (EIQ) (Kovach et al.,1992) for both selecting low impact products, and to assess the cumulative impact of all products applied during the season in each of the six management systems. The EIQ uses 13 criteria including acute and chronic human toxicity, soil and leaf persistence, toxicity to non-target organisms, and leaching and runoff potential to determine worker, consumer/user, and ecological impact—which are combined into one final quotient number. The model balances factors such as toxicity to fish with the probability for the pesticide to leach or runoff the initial application site. The final quotient, or “EIQ number” is produced for all pesticides assessed, and is multiplied by the actual rate of use to give a “field EIQ”. The field EIQ was calculated for each treatment (Figure 3), and differed significantly by cultural management strategy only in the reduced risk treatments. For pest management systems, unrestricted treatments had significantly higher field EIQs than both the IPM and reduced risk treatments.

Figure 3. Environmental Impact of Pesticide Applications, expressed as Field EIQ, 2004

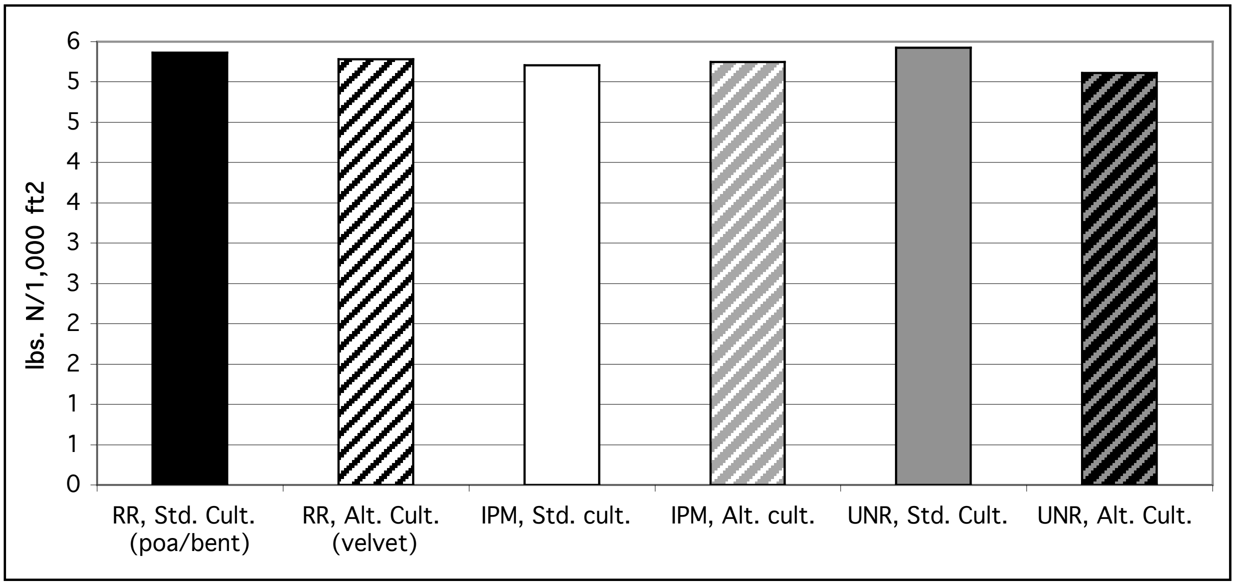


*Treatments with the same letters are not significantly different, (LSD=467.3, p=0.05).

Nitrogen

Nitrogen levels were significantly higher in 2004 for all treatments (Figure 4). This was an unusually wet year and with high sand content root-zones it is not uncommon to need more N to sustain quality and growth as N could be used by more actively growing plants to the lack of heat that would normally cause some slowing in growth.

Figure 4. Total nitrogen applied, 2004



*Treatments are not significantly different (p=0.05).

Labor

Labor resources in 2004 appeared to be allocated substantially different than in previous years where fertility and pesticide applications showed greater differences. In 2004 labor differences were significantly different for cultural management (Table 5). However, it appears that the unrestricted treatments had the highest cultural labor hours that translated into the greatest amount of total labor as compared to the other treatments.

Table 5. Labor hours expended, extrapolated to 18 greens, 2004

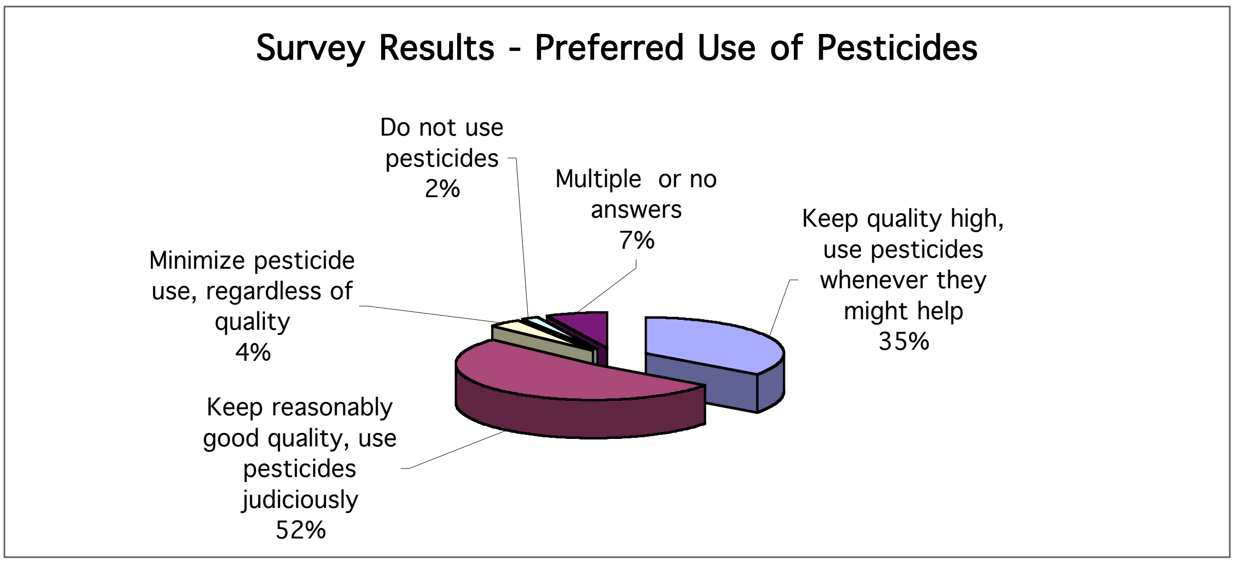
Treatment	Cultural	Fertility	Pest	Total
#1 UNR, Std. cult.	752.3	72.8	40.8	865.8
#2 UNR, Alt. cult.	859.2	85.0	142.2	1086.4
#3 RR, Std. cult.	758.7	60.0	74.1	892.8
#4 RR, Alt. cult.	694.0	76.8	20.8	791.6
#5 IPM, Std. cult.	732.8	68.9	41.6	843.3
#6 IPM, Alt. cult.	693.1	55.2	33.2	781.5
LSD (0.05)	83.5	NS	NS	110.6

Golfer Satisfaction Survey

One hundred and seventy seven golfers were surveyed in 2004 about their perceptions of putting green quality and pesticide use. The survey was purposely conducted in mid-August, to capture golfer perceptions at the time of year that is traditionally the most stressful for the green course putting greens involved in the study. However, as described above, August greens quality was unusually high this year due to a more favorable growing season, i.e. lack of heat and adequate moisture. Survey results were similar to 2003.

The average rating for the visual quality of all greens was between good and very good, and differences by treatment were slight. When asked how they felt about pesticide use on public golf courses, the majority of golfers surveyed once again chose the IPM answer: "Keep greens at reasonably good quality, using pesticides judiciously, only as needed", (Fig. 5). Only 6% of golfers wanted pesticide use reduced if it meant a reduction in quality. In addition, when asked how the Green Course putting greens compared to those of the adjacent Blue and Yellow courses, 28% of golfers considered them to be better or much better.

Fig. 5 Golfer preferences on pesticide use



Outreach and Impact

Results from this study have been publicized in a number of formal and informal settings, in addition to reporting to the USGA. To date we have given over 40 presentations and written 15 reports and articles, reaching several thousand golf course superintendents and environmental advocates. Discussion of this project has opened new dialog in many arenas where interested parties were previously adversarial.

Discussion

Culture and Growth

The 2004 growing season was one of the top five wettest seasons in history as well as significantly cooler than previous seasons. Poor weather resulted in significant reductions in total number of rounds on the course that could have contributed to less stress from traffic.

The greens maintained active growth throughout the season and clearly benefited from regular fertility and PGR applications that improved overall plant stress tolerance as evidenced by the reduction in pest problems compared to previous seasons.

The elimination of the non-chemical treatments does not indicate a surrender but rather a recognition of the lack of alternative controls that are practical in a real world setting as compared to a research plot environment. However, there is string evidence that alternative technologies that are properly integrated can lead to overall reductions in pesticide use.

Pesticide Use

A successful transition to more environmentally compatible putting green management should begin with slight alterations in existing programs for superintendents to fully embrace them. The use of the EIQ is an excellent first step that has already demonstrated some acceptance with the on-site project coordinator/golf course superintendent, Andy Wilson. Wilson currently utilizes the EIQ approach for his decision-making and finds it easy to work with.

As the data clearly indicates, the unrestricted treatments where traditional pesticide technology is used has higher EIQ ratings compared to either population based decisions in the IPM approach or strict use of RR materials.

Also, while a significant effort is invested in disease management, major reductions in insecticide and herbicide use have been achieved and adhered to during the four years of the study. This suggests that many preventative treatments for insects and weed pests may not be needed and further improve the environmental compatibility of the programs.

The regular applications of biological control using *Pseudomonas aureofaciens* TX-1 seemed to have a profound effect on reducing certain foliar pathogens, such as brown patch and dollar spot as compared to other areas on the course and historical infestation levels. There were several occasions when signs of the pathogen were noted previous to an application and then they dissipated following application where they were clearly visible in adjacent areas.

Velvet bentgrass

The velvet bentgrass greens seem to be responding differently depending on location. For example, the 10th green is small and receives a significant amount of ball marks when compared to the other two greens. During the season, even in 2004 with limited environmental stress, it becomes chlorotic and thins. The 15th green being a par 3 also receives significant ball mark damage but due to its size does not seem to suffer as much traffic stress compared to 10. However, the annual bluegrass populations on both greens in increasing. An early season preventative application of Prostar for fairy ring management completely eliminated what was otherwise a chronic problem with these surfaces.

ACKNOWLEDGEMENTS

In addition to the USGA, we would like to thank the Bethpage State Park, Eco Soil Systems, Raven Industries, Toro, the Sustane Corporation, Novozyme, BioWorks, AgreSource, BASF, Commodity Specialists, Cleary's Chemical, Storr Tractor, Plant Food Company, Maxwell Turf Supply Company, Tee-to-Green Sod, Tamson Yeh and Nassau County Cooperative Extension and the Long Island Golf Course Superintendents Association for their generous support of this project.

REFERENCES

Grant, J.A. and F.S. Rossi. 2004. Evaluation of reduced chemical management systems for putting green turf. *USGA Turfgrass and Environmental Research Online*. Vol. 3(4):1-13. http://usgatero.msu.edu/

Kovach, J., C. Petzoldt, J. Degni, and J. Tette. 1992. A Method to Measure the Environmental Impact of Pesticides. New York Agricultural Experiment Station Bulletin #139. Cornell

University, Ithaca, NY, 8pp. Updated version available at
http://www.nysipm.cornell.edu/publications/EIQ.html